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METHOD AND COST OF QUARRYING LIMESTONE AT THE SPEED QUARRY OF THE LOUISVILLE CEMENT CO., SPEED, INDIANA

BY

H. D. BAYLOR

UNITED STATES
DEPARTMENT OF COMMERCE
BUREAU OF MINES
WASHINGTON

This is the first of a series of papers dealing with mining and treatment methods and costs in the nonmetallic mines, quarries, and pits of the United States. These papers are being prepared by officials and engineers of the producing companies in cooperation with the Bureau of Mines and in accordance with an outline prepared by the bureau for the purpose of securing uniform and comparable data.

These papers will eventually cover the entire nonmetallic field embracing both open pit and underground mining as well as dredging and the recovery of mineral products through wells.

After a sufficient number of these reports have been prepared the data contained therein will be combined with that of special studies by bureau engineers and issued as a series of supplementary papers dealing separately with each mining method and with the several operating steps as "Exploration and Development"; "Estimating Reserves"; "Comparison of Mining Methods Based on Labor Efficiency and Cost Data"; "Drilling and Blasting Practice"; "Wage, Contract, and Bonus Systems"; "Mechanical Loading and Hauling"; "Crushing, Screening, and Washing Practice"; and "Storage."

It is hoped that as these papers are published, a number of operating companies will be stimulated to volunteer papers dealing with their own operations for the benefit of the industry as a whole.

Scott Turner

SCOTT TURNER
Director

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

METHOD AND COST OF QUARRYING LIMESTONE AT THE SPEED QUARRY OF THE LOUISVILLE CEMENT CO., SPEED, IND.[1]

By H. D. Baylor[2]

INTRODUCTION

This is the first of a series of papers describing mining methods and costs at cement plant quarries throughout the United States and deals directly with those methods employed and costs obtained at the quarry of the Louisville Cement Co. located at Speed, Ind.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of Mr. J. M. Buchheit, superintendent of quarries, and Mr. H. E. Schoonover, quarry engineer, in furnishing data and in compiling this report.

HISTORY

The Louisville Cement Co., Inc., of Louisville, Ky., operates two cement plants at Speed, Ind., which is about 10 miles north of Jeffersonville, Ind. These are the Speed Portland plant with a daily capacity of 5,000 barrels of Portland cement and the Speed Brixment plant with a daily capacity 3,500 barrels of Brixment cement. The Brixment cement is a mason's mortar material resulting from the development of the manufacture of natural cement.

The original vertical kilns which were used to produce natural cement in 1870 are still in use in the Brixment plant.

The original natural cement plant consisted of 32 vertical kilns, 8 pot crushers, 8 buhrs, and 8 regrinders. The rock was quarried in the immediate vicinity of the mill. All quarry material was hand-picked for quality and size and transported to the kilns by mules and carts. In about 1894 this rock ledge had dwindled in thickness and the overburden had increased to such an extent that further operation was uneconomical.

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6356."

[2] - Vice president and works manager, Louisville Cement Co., and one of the consulting engineers, U. S. Bureau of Mines.

A new quarry was opened 2 miles from the plant and has been operated to date, supplying stone for both the Brixment and Portland mills. This quarry was opened on the south side of a ravine cutting through the property and worked for several years in a southerly direction. The ledge worked was the Silver Creek limestone. As the quarry proceeded to the south the New Albany black shale was encountered in larger amounts and the ledge thinned until it became expensive to operate.

Test pits dug to the north of the ravine showed the absence of the shale with 8 feet of clay as the only overburden lying directly on the limestone. Operations were then moved to the north.

The clay overburden was plowed and removed by wheel scrapers. A Lidgerwood single drum steam hoist was used to pull both plow and scrapers in place of teams.

The rock was drilled by means of two No. 4 Ingersoll Rand piston drills mounted on tripods. These drills cut holes 16 feet deep, starting with a gage of 3 1/2 inches and finishing at 2 1/2 inches. The operating power was steam and the drills averaged 60 feet of holes per 10 hours.

Boulders were shot by mud-capping or by hand-drilling short plug holes and blockholing.

The rock was then hand-picked and loaded into 2-1/2-cubic yard boxes equipped with bails. These were picked up by revolving locomotive cranes and placed on 4-wheel, meter gage trucks which were hauled to the plant in trains of 6 to 14 cars by an 11-ton Porter steam locomotive.

During early operations (in 1897), 14 men were employed loading rock, each man averaging one box per hour for 10 hours. Four men were used in block-holing and shooting boulders. Three men were used in drilling, two on hoisting cranes, nine in stripping, two for clean-up, and one as foreman. The rates of pay were as follows:

1	Foreman	at 17 1/2 cents per hour	$1.75
3	Drillers	at 17 1/2 cents per hour	5.25
4	Blockholers	at 13 1/2 cents per hour	5.40
14	Loaders	at 13 1/2 cents per hour	18.90
1	Hoistman	at 25 cents per hour	2.50
1	Hoistman	at 15 cents per hour	1.50
9	Strippers	at 12 cents per hour	10.80
2	clean-up men	at 11 cents per hour	2.20
			$48.30

The average daily production by 14 loaders, assuming a cubic yard of stone weighed 3,400 pounds, was 600 tons.

The labor cost at that date averaged 60 per cent of the total cost of stone. The cost of quarrying stone in 1897 was $1.34 per ton.

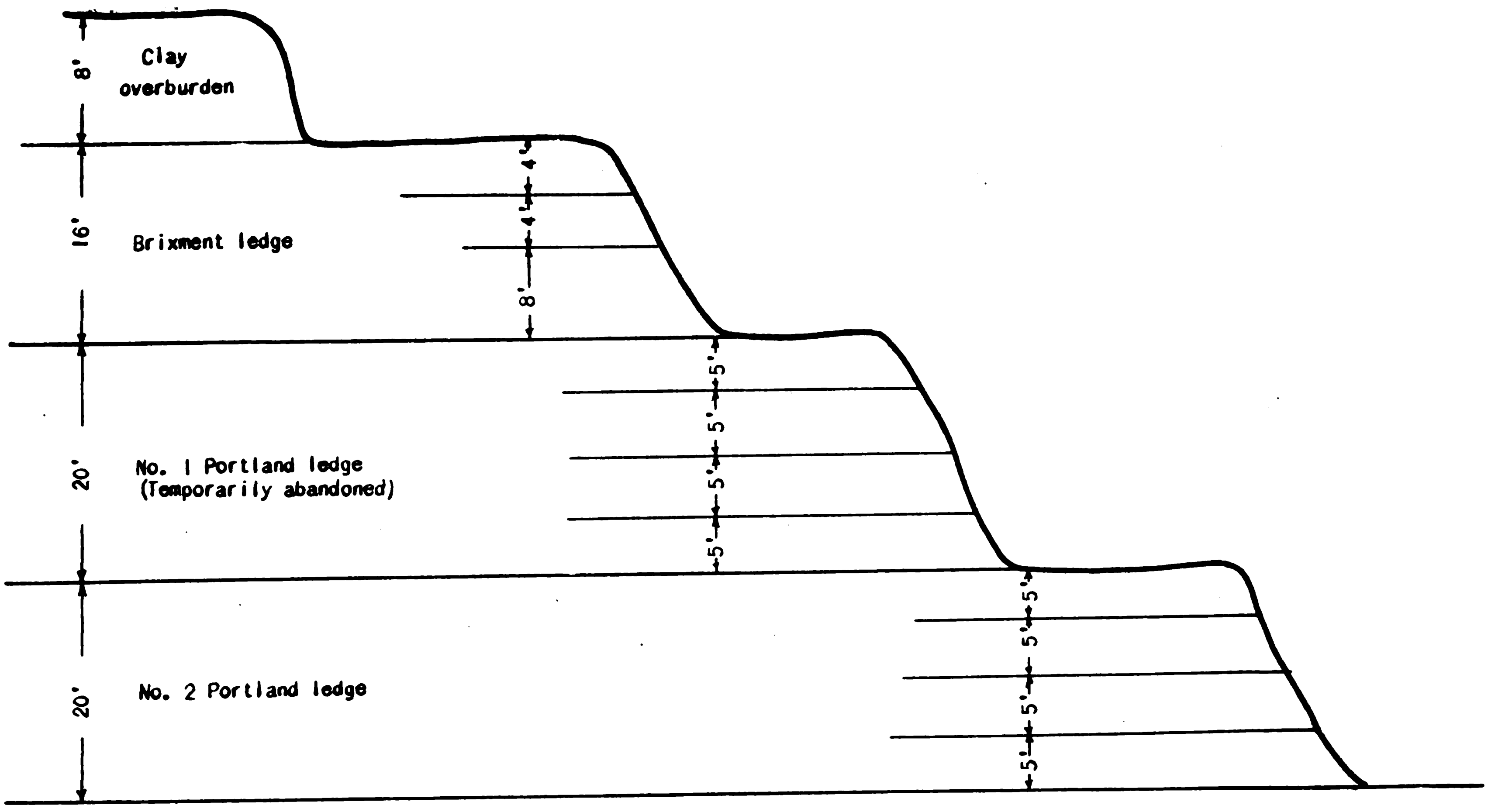

Figure 1.- Cross section of quarry

In 1906 the Speed Portland plant was erected. By test-pitting and core-drilling it was found that 40 feet of the 60 feet of Jeffersonville limestone was suitable for Portland cement, and a 20-foot ledge of this stone was opened up. This ledge consisted of four 5-foot ledges each having a distinct parting seam.

Later, as the Portland production increased, an additional 20 feet of quarry was opened immediately below the original 20-foot ledge of Portland rock. Steam shovels and additional locomotives were purchased to meet this additional rock demand.

GEOLOGY

Rock from this quarry consists of the Silver Creek limestone and Jeffersonville limestone members, of the Devonian age. The Silver Creek formation is 16 feet thick and consists of a fine grained, bluish to dark gray, argillaceous limestone.

The Jeffersonville, lying below the Silver Creek, is 60 feet thick, ranges from white to bluish and buff in color, and is a coarse grained, cherty, argillaceous stone.

A noticeable feature of both formations is the absence of caves, fissures, slips, sink holes, and mud seams, except on the surface immediately below the clay.

All ledges lie in a horizontal position, and there are free parting seams between all beds. This parting forms a remarkably level quarry floor and excellent working conditions for track and shovel operation.

Figure 1 is a diagramatic section through the quarry showing the various strata and the thickness of the beds within the strata.

Table 1 gives the chemical analyses of the various beds.

Table 1. - Chemical analyses chart

	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	$CaCo_3$	$MgCo_3$
8-foot overburden (clay)	67.98	19.53	7.62	11.91	10.45	5.72
4-foot Silver Creek limestone	10.50	5.66	-	-	64.54	19.72
4-foot Silver Creek limestone	16.20	6.72	-	-	54.63	22.83
8-foot Silver Creek limestone	14.32	6.90	-	-	61.75	17.48
5-foot Jeffersonville limestone	15.04	2.00	-	-	77.19	5.77
5-foot Jeffersonville limestone	3.26	.70	-	-	90.81	4.64
5-foot Jeffersonville limestone	3.60	1.54	-	-	92.22	3.64
5-foot Jeffersonville limestone	4.46	.48	-	-	91.04	4.02
5-foot Jeffersonville limestone	2.64	.58	-	-	94.65	2.13
5-foot Jeffersonville limestone	5.40	.74	-	-	91.51	2.35
5-foot Jeffersonville limestone	.74	.54	-	-	93.33	5.39
5-foot Jeffersonville limestone	3.56	.30	-	-	50.64	18.24
20-foot Jeffersonville limestone	30.60	1.77	-	-	46.46	21.17

Below the 40-foot level this Jeffersonville limestone is not fit for Portland cement purposes. This rock, however, could be used for commercial stone.

METHODS OF PROSPECTING AND EXPLORATION

Preliminary exploration in this quarry was accomplished by means of test pits in and near our present operation. Later on a diamond core drill was used and an accurate record kept of the findings. There are no records available on these core-drilling costs, however.

SAMPLING

Samples of the crusher run of rock are taken daily and a weekly analysis is run. The rock analysis over a year's run shows very little variation. The overburden, which is clay, has no value at present.

CHOICE OF METHOD

The horizontal position of the limestone ledges under a comparatively light and easily handled overburden made the choice of open quarrying automatic.

When the need for Portland rock arose, those ledges of Jeffersonville limestone uncovered by the removal of the Brixment stone offered an ideal source of raw material at a minimum of expense. A second bench in the original quarry was opened in the floor, taking the upper 20 feet of the Jeffersonville limestone and later as the demand for stone increased a third bench was opened taking a second 20 feet of this stone.

As a result the quarry now supplies an average of 9 tons of stone per ton of overburden removed.

As noted previously, early prospecting was done by means of test pits followed by core-drilling with careful records of the chemical composition of the material cored.

The drainage problem is taken care of by means of a 4,000-gallon per minute sump pump direct connected to a 100-hp. motor. The drainage area surrounding the quarry takes in about 200 acres. Very little trouble is experienced with water, however. This lower quarry floor has about 1 per cent dip to the west and the sump is located at the lowest point. In wet weather water accumulates in the western edge of this lower floor and quarrying in this section is abandoned until dry weather sets in.

The company owns several hundred acres of land in the immediate vicinity of the quarry, all of which is underlain with desirable rock. Part of this is leased for farming purposes until further expansion of the quarry.

As will be noted from the quarry plan (fig. 2) the quarry faces are all carried in the arc of a circle. Experience has proven that better fragmentation results when breaking from a circular face than when blasting the stone in a straight line.

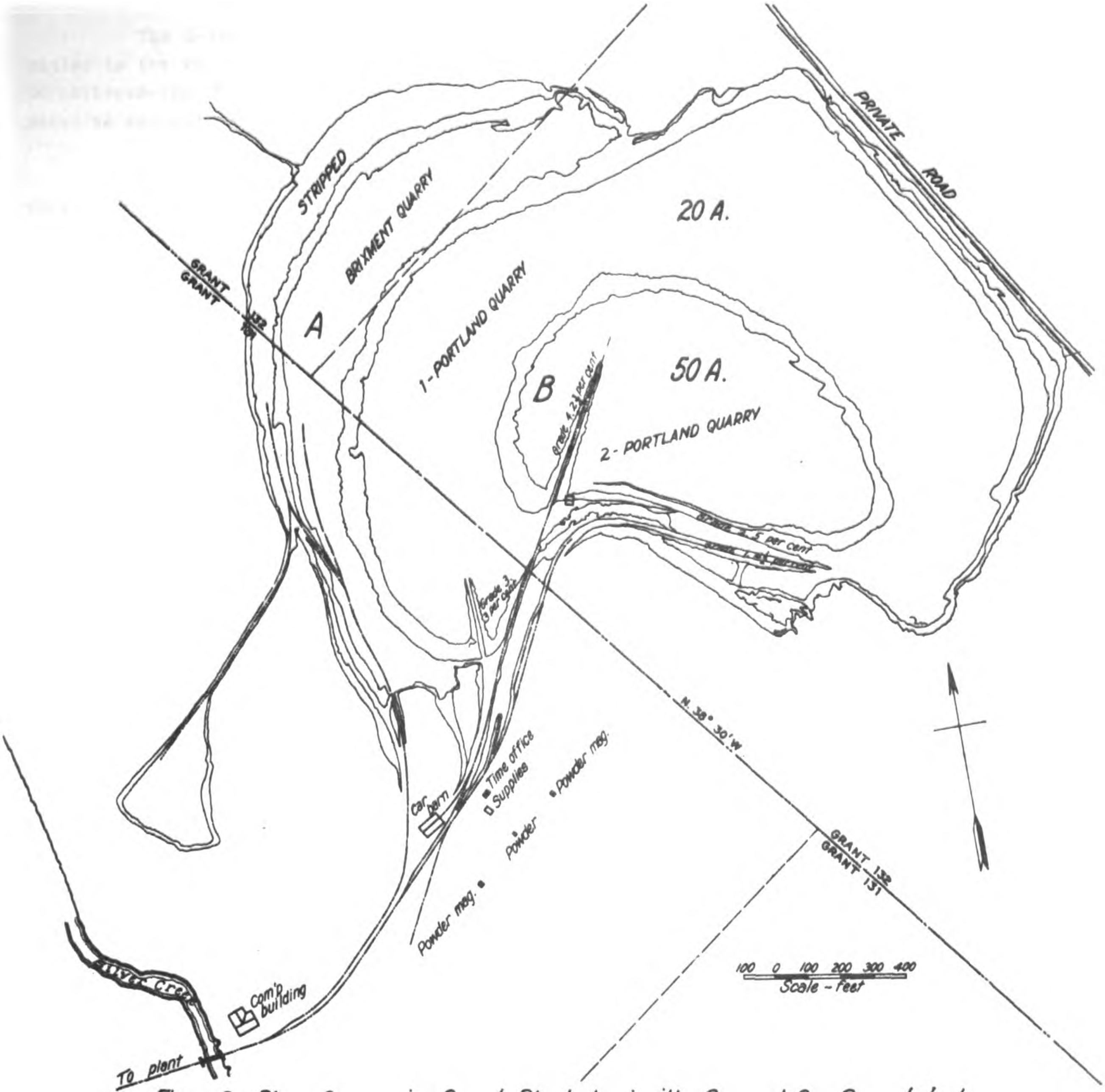

Figure 2.- Plan of quarries, Speed Plant, Louisville Cement Co., Speed, Ind.

MINING METHODS

Stripping

The 8-foot clay overburden has at present no commercial value and is removed and hauled to the waste dump as shown on the quarry plan (fig. 2). The clay is dug with a Model 60 railroad-type Marion steam shovel, equipped with a 2 1/2-cubic yard dipper. The shovel is moved on sections of 70 pound rails ranging from 5 to 7 feet in length.

The stripping crew of 17 men, consists of an engineer, craneman, and fireman on the shovel; four pitmen; a foreman; a locomotive engineer; a brakeman; and six dumpmen.

The shovel loads the clay into 5-cubic-yard 2-way dump cars handled in trains of 10 cars. These cars are hauled to the dump, a distance of 1/4 to 3/4 mile and averaging 1/2 mile.

The dump track was built on one slope of a ravine running to the west of the quarry and has been lengthened until it is now approximately 1/4 mile in length and 30 feet high. This dump will handle about 32 hours of stripping without any movement of track.

Stripping is intermittent throughout the dry seasons of the year. inasmuch as the Portland quarry rock production is such that 3 1/2 to 4 days operation give the required tonnage for the week. These Portland quarry operators are then used on the stripping operation for the balance of the week. This switching of men makes it possible for the Portland quarry crews to have steady employment.

During 1929 stripping operations lasted 613 hours with an average removal of 157 tons per hour, or 1,256 tons per 8-hour day.

This rate of removal of overburden will readily keep ahead of the quarrying.

BRIXMENT QUARRY

As previously noted the Brixment quarry removes the first ledge of Silver Creek limestone and is shown at A on the quarry plan (fig. 2).

This ledge has an average production of 656 tons per 8-hour shift.

The quarry has a Marion, Model 60, steam shovel equipped with a traction crawler outfit and a 2 1/2-cubic yard dipper. Three men are used on the shovel as on stripping, besides one foreman, one jackhammerman, and one pitman. Six-yard cars are used in trains of 9 cars each which are hauled to the plant by means of an 18-ton Porter locomotive.

All rock from this ledge is used with no waste handling necessary.

PORTLAND QUARRY

The first 20-foot ledge of Jeffersonville limestone uncovered by the advance of the Brixment quarry was abandoned in December, 1927. This quarry face includes about 70 acres stripped and ready for quarrying (A, fig. 2). As previously worked, one Model 60, Marion steam shovel operated on this ledge, but when the lower ledge (B, fig. 2) was opened the shovel was removed to the lower level and another similar shovel added. This system made a more economical operation as one locomotive was eliminated from the operating schedule.

To work this lower ledge economically it was necessary to construct a grade of 2 3/4 per cent about 2,000 feet long into the quarry (No. 4, fig. 2). Originally there were two grades, one 1,500 feet long about 4 1/2 per cent and another 1,200 feet long about 5 per cent. (Nos. 1 and 2, fig. 2.)

This new grade shortened the haul from the quarry about 700 feet and made it possible to use a 9-car train where before only a 6-car train had been used. The two shovels in this lower quarry operated 1,445 and 1,453 hours, respectively, during 1929 with a total tonnage of 309,910, an average of 107 tons per hour per shovel. Both of these shovels have a crew of three men on the shovel and a foreman and block-hole driller in the pit. Each was formerly a railroad-type shovel but both are now equipped with traction crawler outfits. This quarry has a 20-foot face about 3,300 feet long in the arc of a circle. There are about 50 acres of this quarry opened up and about 20 acres remain to be quarried before the abandoned upper ledge is reached.

DRILLING AND BLASTING

Bruxment Quarry

The primary holes on the Brixment ledge are drilled with one Ingersoll-Rand X-70 Leyner drifter mounted on a 4-wheel wagon (fig. 3). This is a piston drill operating on compressed air at 90 pounds per square inch at the drill. The drill will cut 250 feet of 2-inch holes per 8-hour shift. Formerly one Ingersoll-Rand Turntable drill was used but this was displaced by the X-70 because of lower operating costs and increased drilling speed.

The original turntable type of drill drilling holes 4 inches in diameter cut 8 feet per hour.

The X-70 drill has been found very adaptable to the low ledge method used in this quarry.

Holes drilled by the original turntable drills were 16 feet deep and were spaced 8 feet from the face of the ledge and 10 feet apart, giving a break of 134 tons per hole or 8.4 tons per foot of hole. Three holes per 8-hour day per drill produced an average of 402 tons per drill per day.

Four men were required to operate these drills and it was necessary to operate them 12 to 14 hours a day 7 days a week to keep ahead of the shovel. This type of drill was very unsatisfactory and the repair cost was high.

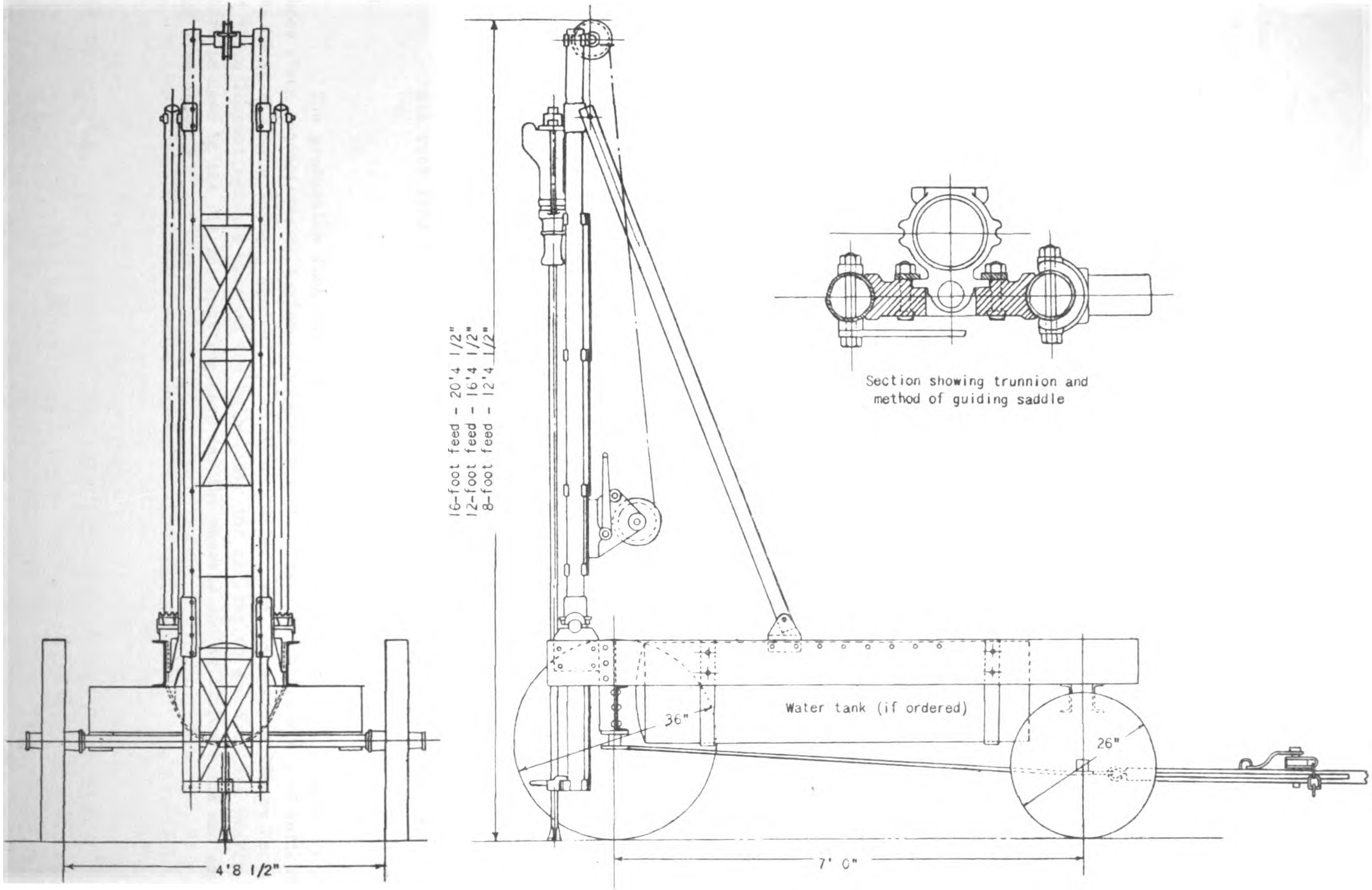

Figure 3.- Wagon-mounted air drill

The Ingersoll-Rand X-70 Leyner drifters were installed as wet drills but it soon became apparent that greater footage could be obtained using these drills without water. This quarry now averages 200 feet per 8-hour day per drill with a spacing of 7 by 8 feet which gives a drilling duty of 940 tons per drill or 2.3 times the tonnage of the older type drills.

A 1 1/4 inch hollow round drill steel with four changes of bits, 5,-10,-15 and 20 feet in length is used. These are 4 point, 15° bits and are gaged from 2 3/4 to 2 1/4 inch.

Two lines of holes are drilled on a 7 by 8 foot spacing and the back line holes are staggered between holes of the front line.

PORTLAND QUARRY

The Portland primary drilling is handled similarly to that on the Brixment ledge and hole spacings are the same. However, there is one X-70 Leyner drifter and an X-71 drifter on this ledge. The two drills are handled by two drillers and one helper. These drills will average 200 feet each per 8-hour day. An average of 90 to 100 holes are shot simultaneously.

Drilling costs average 5 cents per foot of hole including power. Repair costs average $0.0014 per foot of hole; 40 and 60 per cent Trojan R2 Dynamite in 2 by 18 inch cartridges are loaded in column loading. Cordeau Bickford fuse is used on all primary shots. One No. 8, 12-foot electric detonator is used at each end of the Cordeau Bickford trunk line. Shots are made by electric exploding machine of the hand operated magneto type.

In secondary blasting all large rocks are drilled by means of Jackhammers and then shot with 40 per cent dynamite.

There is no means of accurately knowing the ratio of stone broken by secondary blasting to that by primary, but for both ledges it is estimated that 3 per cent of the primary blast is block-holed and shot in the secondary blasting.

All rock from this quarry is used in the manufacture of Portland cement.

TRANSPORTATION

The production from the Portland quarry is transported to the plant by means of three steam locomotives in trains of nine cars each. These locomotives are of various sizes, one being a 33-ton Vulcan, another an 18.5-ton Porter, and the third a 15-ton Porter. Two of these locomotives are used on the main lines for hauling to and from the quarry and the third is used in the Pit for spotting cars for the shovels and switching loads and empties to and from shovels.

There are about 1 3/4 miles of double track from the plant to the quarry. One locomotive is used for transporting rock from the Brixment quarry.

The internal quarry trackage system may best be understood by a study of the accompanying sketch (fig. 4).

A track foreman and six men maintain the track in the quarry, on the waste dump, and on all main lines to the quarry, spending about 2 days per week on quarry tracks, 1 day on main lines and Brixment, and 3 days on dump.

CLEAN-UP SHOVEL

During 1928, 5,262 man-hours of labor, costing $2,631.00, were employed in cleaning quarry floors after the passage of loading shovels. During 5 months of 1929, this expense had increased to 3,118 man-hours, costing $1,559.00.

To decrease this expense a small 3/5-yard shovel, mounted on a tractor, was purchased at a cost of $3,000.00. In 1929 and 1930, this unit has more than repaid its cost in clean-up work and on construction excavation around the plant. Figure 5 illustrates this unit.

CRUSHING PLANT

The Brixment crushing plant consists of a 36 by 48 inch Traylor "Bulldog" jaw crusher, belt driven by a 125-hp., 3-phase, 60 cycle, 700-r.p.m., 440-volt motor. The rated capacity of this crusher is 100 tons per hour. No secondary crushing is necessary in this operation, and the discharge from this crusher is less than 7 inches in size.

The product from this crusher passes over a bar grizzly with 1 5/8-inch openings, which removes the fines ahead of the kilns. These fines are sent to the Portland plant or sold as ballast as occasion arises.

The Portland crushing plant consists of a gyratory crusher, inclined elevator, feed hopper, apron feeder, hammermill, vertical elevator, and shuttle belt.

The gyratory crusher is a Gates No. 24, manufactured by the Allis-Chalmers Mfg. Co. It has a rated capacity of 600 tons per hour with a discharge setting of 4½ inches and is driven by a 200-hp., 3-phase, 60-cycle, 505-r.p.m., 440-volt motor through an Allis-Chalmers Texrope drive on 10 foot-7½ inch centers. The material from this crusher discharges into a 54 foot inclined belt elevator which has sixty 17 by 21 inch buckets on 24-inch centers.

A 75-hp., 3-phase, 60-cycle, 580-r.p.m., 440-volt motor, coupled to a No. 36 Jones spur gear speed reducer having a 3 to 1 ratio is used for driving this elevator, which is inclined at 75°. The rock passes from the inclined elevator to the feed hopper which has a capacity of 34 tons, and from there it is discharged onto an apron feeder that conveys it to a Pennsylvania hammermill which is the only secondary crushing unit used. This process re-

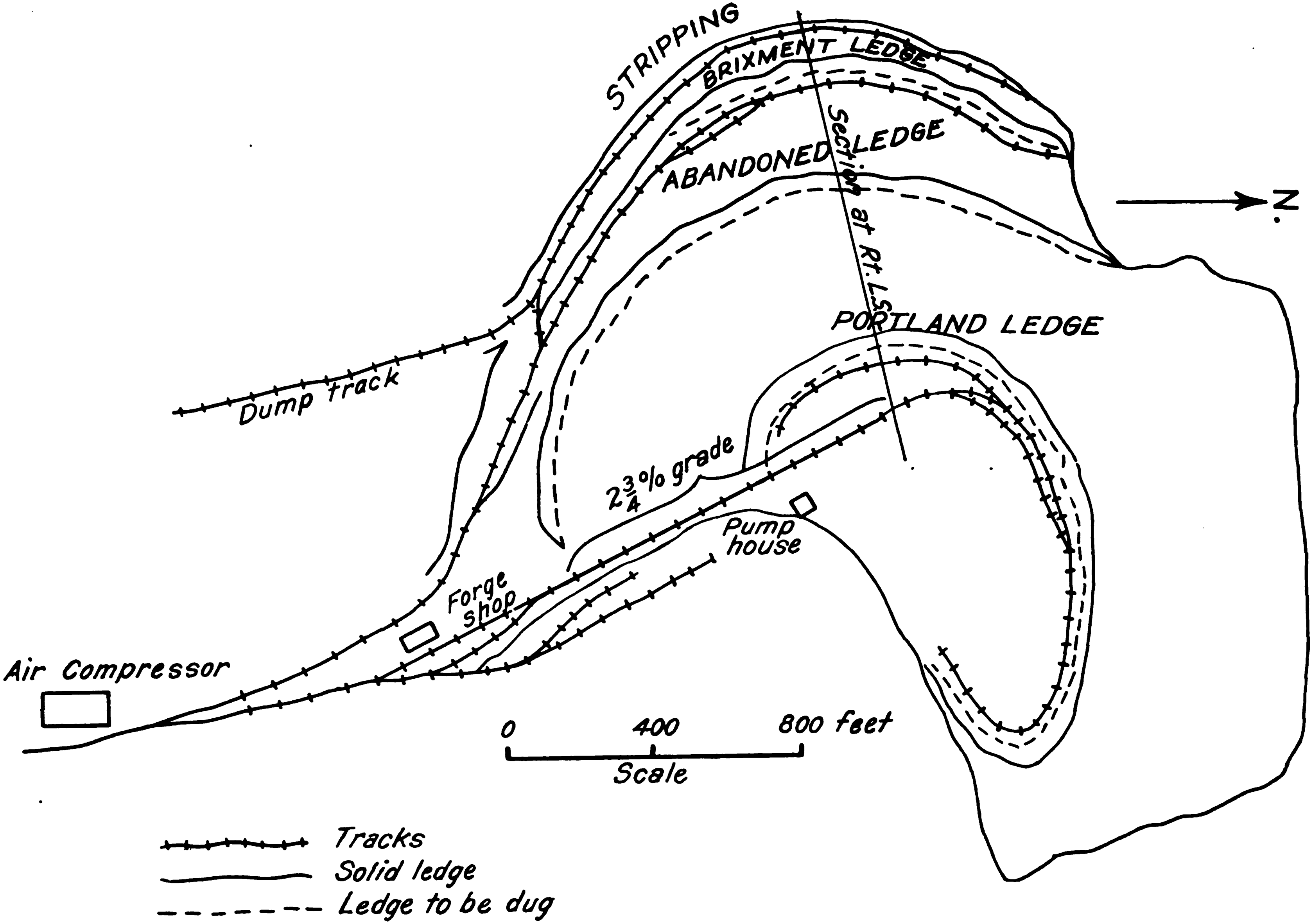

Figure 4.–Quarry internal track layout

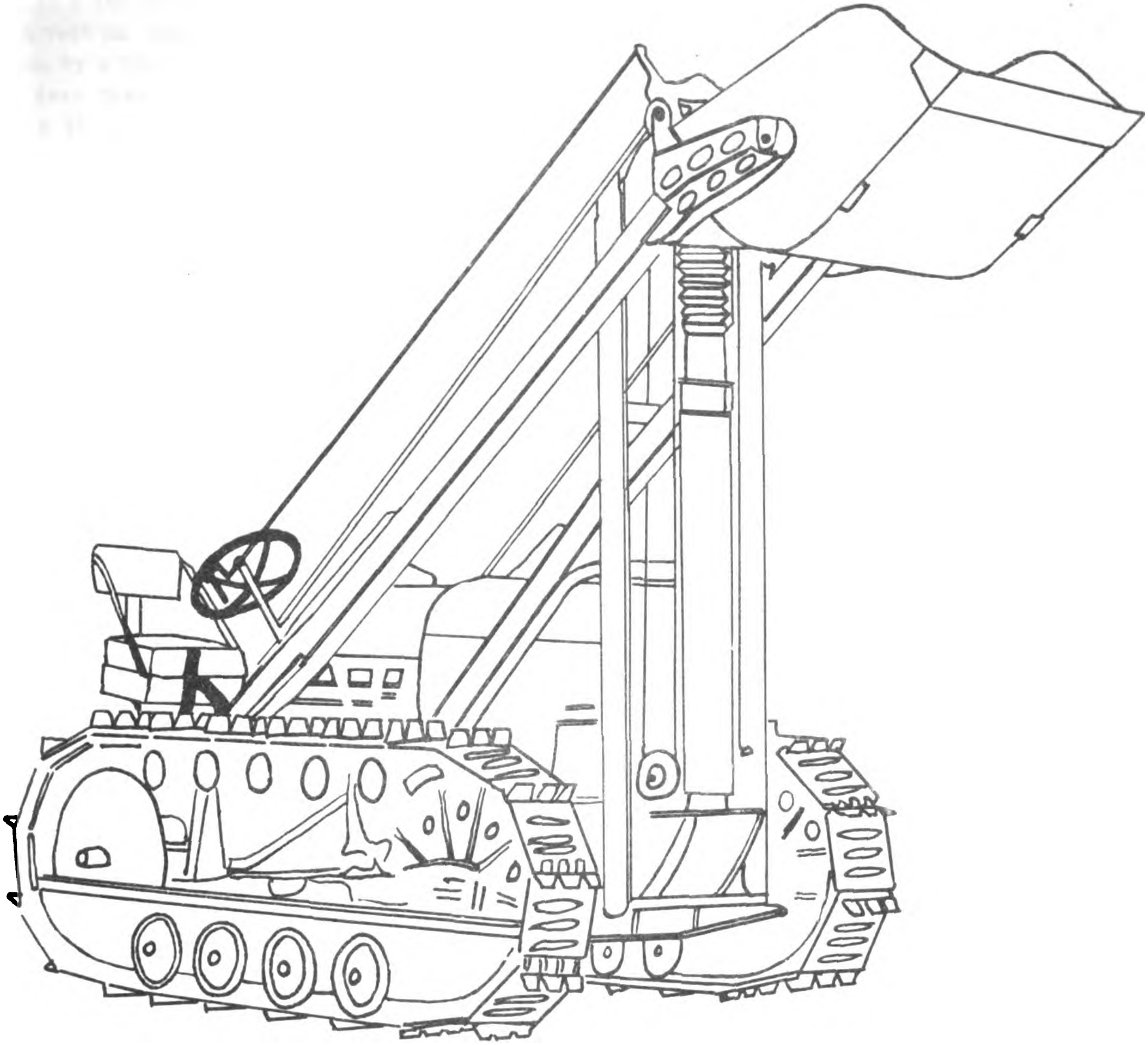

Figure 5.- Clean-up shovel

duces the product to a material ranging in size from 1 inch to dust. This hammermill has a rated capacity of 300 tons per hour and is driven by a 200-hp., 3-phase, 60-cycle, 705-r.p.m., 440-volt motor direct connected. A vertical elevator carries the discharge from the hammermill to a 26-inch shuttle belt which discharges into the rock storage. The vertical elevator is 54 feet on centers and has forty-eight 15 by 12¼ inch buckets on 18-inch centers. It is driven by a 25-hp., 60-cycle, 3-Phase, 575-r.p.m. 440-volt motor coupled to a No. 24 Jones spur gear speed reducer having a ratio of 3 to 1. The Shuttle belt has 20-inch tail pulleys with a 26-inch face and is 89 feet overall. It is operated by a motor-driven winch.

WAGE SCALE

All wages are paid on an hourly basis and the following chart will give a fair idea of the type of labor.

Position	Number in quarry	Wage per hour
Engineers	3	$ 0.65
Craneman	3	.55
Firemen	3	.52½
Foremen	3	.65
Drillers	3	.48
Trackmen	8	.43
Drillers	3	.58
Drill helpers	2	.55
Locomotive engineers	4	.58½
Brakemen	4	.48
Blacksmith	1	.72
Helper	1	.55
Car repairmen	2	.56

SAFETY ORGANIZATION

Safety work has been carried on at this plant on an extensive scale for about eight years. The plant was formerly subdivided into nine safety divisions with men of similar occupation grouped as near together as possible, each division had its own safety captain and first-aid squad. Monthly meetings were held by these divisions, and speakers and personnel men of the plant brought safety education to these men as a unit. All safety work was carried on by the personnel department, consisting of the plant superintendent, chief clerk, and first aid men. Various safety contests and campaigns were arranged to stimulate interest.

In 1928, it was decided to place this safety work on a production basis, and the work was turned over to the operating departments. There are now three divisions consisting of the quarry, including the Brixment and Portland quarries and the stripping operation; the kilns, including the breaker, mill, and packing house; and the carpenters, iron workers, repair men, locomotive and track men, etc.

Each division meets monthly and reports and discusses unsafe conditions and practices. They make suggestions and reports which are subject to veto by the superintendent but only after thorough study and careful explanation to support the veto.

This move was made because it was felt that over an 8-year educational period the men have become well enough acquainted with the work to carry it on themselves. The responsibility has been placed on the general foremen, subforemen, and the man, himself, and the men feel this responsibility and are doing nicely. As an example, the quarry division has gone 6 years and 2 months without a lost time accident, this being the most outstanding record in the country to date.

MANAGEMENT

Figure 6 is a chart showing the delegation of authority.

The superintendents of the various departments throughout the company organization call foremen's meetings three or four times a year for round-table discussion of operating problems.

Weekly meetings are held by the heads of departments to which others are summoned when problems under their particular supervision are under discussion.

Cost per ton of overburden

Period covered .... 1929 Tons produced 96,520

	Labor	Power	Fuel	Miscellaneous	Total
Loading	$0.0450		$0.0085	$0.0170	
Transportation	.0120		.0160	.0235	
Disposal	.0400				
Cost per ton overburden	.0970		.0245	.0405	$.1620
Cost per ton rock uncovered					.0254

Cost per ton of Brixment rock

Period covered .... 1929 Tons produced 160,520

	Labor	Drill Steel	Power	Fuel	Explosives	Miscellaneous	Total
Drilling primary	$0.0100	$0.0050					$0.0150
Drilling secondary	.0080	.0050					.0130
Blasting primary	.0050				$0.0250		.0300
Blasting secondary	.0025				.0050		.0075
Loading	.0742		$0.0037	$0.0066		$0.0125	.0870
Transportation	.0300			.0066		.0234	.0500
Miscellaneous overhead (Local and plant office						.0175	.0175
Stripping cost						.0254	.0254
Total cost	$0.1297	$0.0100	$0.0037	$0.0132	$0.0300	$0.0788	$0.2654

Cost per ton of Portland rock

Period covered .... 1929 Tons produced 309,910

	Labor	Drill Steel	Power	Fuel	Explosives	Miscellaneous	Total
Drilling primary	$0.0100	$0.0050					$0.0150
Drilling secondary	.0050	.0050					.0100
Blasting primary	.0050				$0.0350		.0400
Blasting secondary	.0025				.0069		.0094
Loading	.0423		$0.0037	$0.0066		$0.0358	.0884
Transportation	.0250			.0066		.0703	.1019
Miscellaneous overhead						.0300	.0300
Stripping cost						.0254	.0254
Total cost	$0.0898	$0.0100	$0.0037	$0.0132	$0.0419	$0.1615	$0.3201

Summary of quarry costs

Period covered 1929

	Stripping	Brixment	Portland
A. Labor			
Drilling		$ 0.0180	$ 0.0150
Blasting		.0075	.0075
Loading	$ 0.0450	.0742	.0423
Haulage	.0120	.0300	.0250
Miscellaneous	.0400		
Total Labor	.0970	.1297	.0898
Average tons per man per shift	110	65.6	85.6
Labor cost, per cent of total cost	60	41	28
B. Power and supplies			
Explosives		$ .0300	$ .0419
Shovels	.0170	.0125	.0358
Locomotives	.0235	.0234	.0703
Air compressors		.0032	.0032
Drills		.0100	.0100
Pumps		.0005	.0005
Fuel (coal)	.0245	.0132	.0132
Overhead		.0175	.0300
Total cost	.0650	.1103	.2049
Cost summary			
Labor cost	.0970	.1297	.0898
Stripping cost		.0254	.0254
Power and supply cost	.0650	.1103	.2049
Total cost per ton	$ 0.1620	$ 0.2654	$ 0.3201

Quarry man-hour table

(Period covered, average month in 1929)

	Stripping			Brixment			Portland		
	Tons	Man hours	Man hours per ton	Tons	Man hours	Man hours per ton	Tons	Man hours	Man hours per ton
Foremen	17,670	212	0.0120	11,770	248	0.0210	28 860	450	0.0156
Powder				11,770	140	.0119	28,860	427	.0149
Drillers				11,770	140	.0119	28,860	288	.0100
Shovel engineers	17,670	106	.0060	11,770	140	.0119	28,860	288	.0100
Shovel cranemen	17,670	106	.0060	11,770	140	.0119	28,860	288	.0100
Shovel fireman	17,670	106	.0060	11,770	140	.0119	28 860	288	.0100
Locomotive engineer	17,670	106	.0060	11,770	193	.0164	28 860	432	.0149
Locomotive brakemen	17,670	106	.0060	11,770	193	.0164	28,860	432	.0149
Drillers				11,770	258	.0212	28,860	386	.0134
Dump men	17,670	636	.0360						
Pit men	17,670	770	.0436						
Track maintenance	17,670	240	.0135	11,770	162	.0139	28,860	300	.0104
Shovel repair				11,770	53	.0045	28,860	98	.0034
Totals	17,670	2388	.1351	11,770	1807	.1529	28,860	3677	.1275

Crushing cost

	Brixment	Portland
Operating labor	$0.0270	$0.0136
Operating supplies	.0055	.0028
Repair labor	.0051	.0028
Repair supplies	.0060	.0100
Power	.0100	.0068
Overhead and depreciation	.0400	.0500
Totals	$0.0936	$0.0860

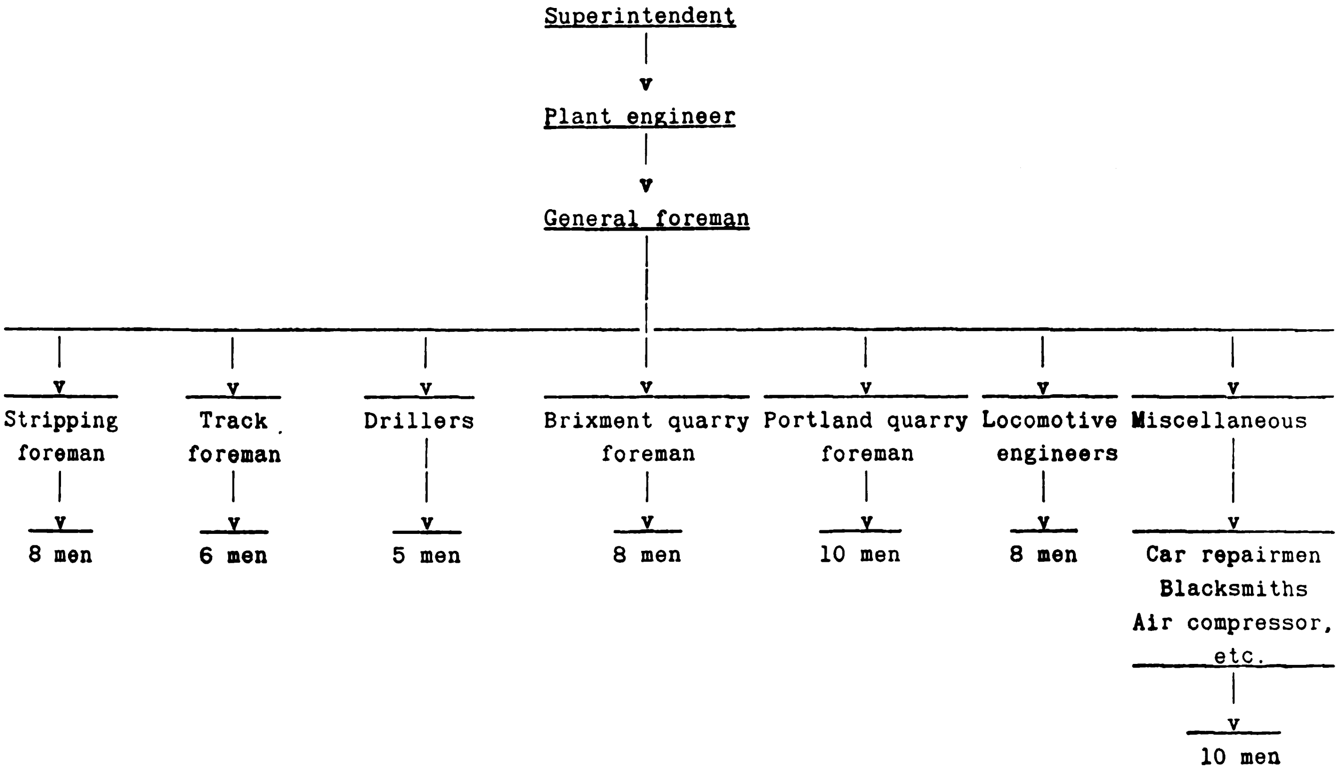

Figure 6. - Chart showing delegation of authority at Speed quarry